Environmental Fluid Dynamics Code (EFDC)

The Environmental Fluid Dynamics Code (EFDC) is a state-of-the-art hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions. It has evolved over the past two decades to become one of the most widely used and technically defensible hydrodynamic models in the world. EFDC uses stretched or sigma vertical coordinates and Cartesian or curvilinear, orthogonal horizontal coordinates to represent the physical characteristics of a waterbody. It solves three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable-density fluid. Dynamically-coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The EFDC model allows for drying and wetting in shallow areas by a mass conservation scheme. The physics of the EFDC model and many aspects of the computational scheme are equivalent to the widely used Blumberg-Mellor model and U. S. Army Corps of Engineers' Chesapeake Bay model. EFDC's role in the TMDL Toolbox will be to provide necessary hydrodynamic inputs to WASP, the advanced receiving water quality model.

EFDC Preprocessor

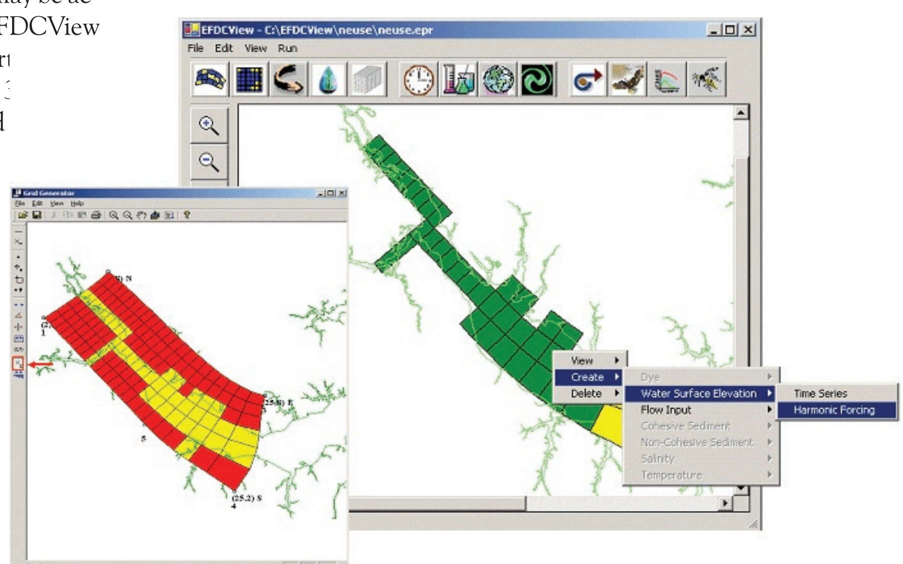
A preprocessor is being developed to facilitate the setup and application of EFDC for a wide range of applications. The preprocessor provides three significant tools to streamline the setup of an EFDC model: the VOGG Curvilinear Grid Generator, the EFDCView Model Interface, and the MOVEM Postprocessor. The VOGG Grid Generator and MOVEM postprocessor are stand-alone applications that may be accessed via the EFDCView environment. EFDCView enables the user to generate curvilinear-ort grids, simulate aquatic systems in 1, 2, or sions, link 2-D grids to 1-D grids, quickly and and change critical modeling parameters, and make use of watershed loading model results and monitoring data for boundary conditions.

The VOGG Curvilinear Grid Generator enables a user to generate curvilinear-orthogonal grids that are required by EFDCView. It significantly decreases the repetitive effort typically required through manual grid generation methods. Grid generation is conducted interactively and intuitively through the interface and associated controls. Key features of the tool include:

- GIS interface
- Model domain designation through user control point designation
- Automatic insertion of grid boundary points based on control point designation
- Automatic curvilinear-orthogonal grid generation
- Model grid conversion to GIS shape file format
- Cell mapping between EFDC and WASP

Once a grid has been generated, it's necessary to set and calibrate pertinent modeling parameters. EFDCView simplifies the setup and application of EFDC through a shapefile format-based graphical interface and associated windows. It supports input of EFDC model run control and model parameter designation, and it links directly to boundary condition/source data, e.g. watershed model output and point source contributions. Key features of the tool include:

- Visual linkage to the model grid
- Visual linkage to point and nonpoint source inputs
- New model parameter addition and accommodation
- Direct linkage to WRDB for boundary condition designation/generation



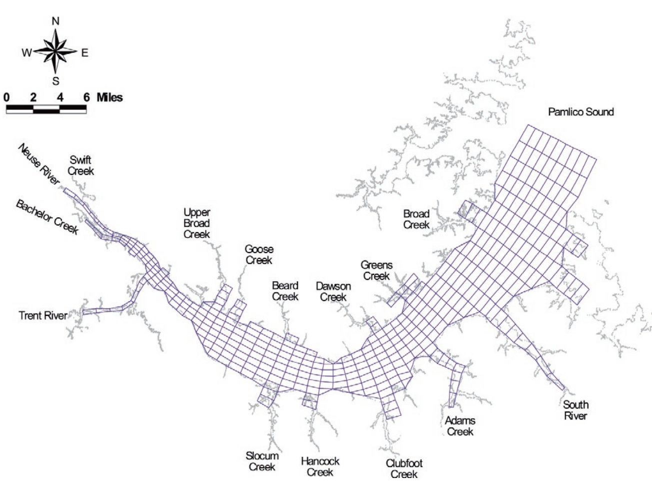
EFDC Application for the Neuse River Estuary, NC

The Neuse River Estuary was included on the State's 303(d) list for nutrients and was scheduled for TMDL development by the spring of 2001. The water quality targets within the system are based ultimately on chlorophyll-a concentrations. The target of 40 mg/L chlorophyll-a will be achieved within the Neuse Estuary through control of point and non-point discharges of nutrients, specifically nitrogen, within the Neuse River watershed and tributaries adjacent to the estuary.

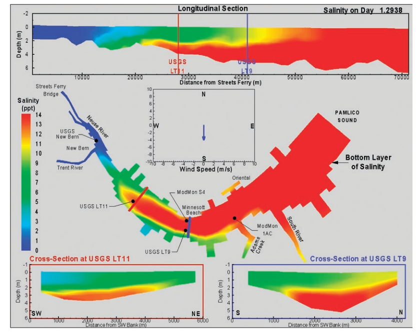
Background

The Neuse River Estuary is located in eastern North Carolina at the confluence of the Neuse River and Pamlico Sound. The Neuse River is 179 miles long and it's watershed drains approximately 5,700 square miles from the coastal plain and piedmont provinces of the state. There have been significant concerns with the water quality in the estuary over the past decade, with a focus on nutrient loadings from surrounding land uses.

The circulation and transport of materials within the Neuse Estuary are highly complex. Water surface elevation fluctuations within Pamlico Sound are on the order of 1 meter and provide a driving mechanism at the mouth of the estuary. These fluctuations are caused primarily by meteorological events creating "sloshing" within the Sound. Salinity intrusion to the system extends nearly 45 miles into the estuary and creates the characteristic residual estuarine circulation pattern



of outflow on the surface and inflow at the bottom. Finally, local wind forcing creates conditions where the stratification within the estuary is overturned periodically altering the residual flow patterns.



Water quality within the Neuse Estuary is highly influenced by the complex circulation patterns. System characteristics include seasonal low dissolved oxygen near the bottom, areas of low flow and flushing causing algal blooms, overturning of low dissolved oxygen water where significant wind events follow periods of low energy, and backwater effects caused by set up of water surface elevation within Pamlico Sound.

TMDL Summary

In 1999 the State of North Carolina proposed to EPA Region 4 an initial target of 30 percent reduction in total nitrogen load from the Neuse River to the estuary. This work was Phase I of the Neuse Estuary TMDL. This initial reduction target was not determined through detailed model application and evaluation.

Under Phase II of the Neuse Estuary TMDL development, and in agreement with the State of North Carolina, EPA is utilizing the Environmental Fluid Dynamics Code (EFDC), a three-dimensional hydrodynamic model, linked with the EPA Water Quality Analysis and Simulation Program (WASP) to determine the level of nutrient reduction required for the Neuse Estuary to meet the designated uses. The Hydrological Simulation Program FORTRAN (HSPF) and Nonpoint Source Model (NSPM) were utilized in conjunction with US EPA Region 4's Watershed Characterization System to provide loads directly to the estuary model.

The model was applied over a 3-year period, examining the chlorophyll-a levels in the system, both longitudinally distributed as well as lateral variations. In addition to examining the effects of nutrients on chlorophyll-a concentrations, EPA will be able to determine the frequency of anoxic conditions in the lower waters of the estuary due to nutrient enrichment, and the benefits gained (relative to dissolved oxygen) through nutrient reduction.

Visit the
Watershed & Water Quality Modeling
Technical Support Center Website
http://www.epa.gov/athens/wwqtsc/index.html